§4. Measurement of Dynamic Property of Pulse Modulated Induction Thermal Plasmas Using Langmuir Probes

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Thermal plasma technology has been applied for various industrial fields at present like material, surface etching and deposition. For these thermal plasma applications, it is very important to investigate properties, such as the plasma density, temperature, flow velocity and so on. Moreover, We are trying to material processing experiments1) using a new type of Inductively Coupled Thermal Plasma (ICTP) that is called Pulse-Modulated Induction Plasma (PMITP). The PMITP is thermal plasmas under the periodical transient state by amplitude modulation of coil current maintaining ICTP. This plasma has possibilities of controlling thermal plasma temperature and radical density in time domain. However, little is known about the dynamic plasma properties. In this work, we investigate dynamic behavior of electron density and temperature in Ar-PMITP using Langmuir probe.

In this experiment, the plasma mean input power was kept at 15 kW. Ar gas pressure was 30 kPa. Ar gas flow rate was 100 slpm. We measured electron density and temperature by Triple probe method and Ar excitation temperature by spectrometer in PMITP, when SCL (Simmer Current Level) is changed. The SCL is current modulation ratio that expressed as minimum current amplitude divided by max current amplitude. The reason why triple probe method is used in this measurement is that it is possible to investigate under the transition state because it needs no sweeping voltage.

Figure 1 shows time evolution of the center electron density and temperature at SCL=60% and 100%. The electron density changes synchronously with the rf power modulation, but the electron temperature shows a different behavior from that of the electron density. The electron density shows a simple behavior corresponding to a rectangular change of the rf power. Figure 2 shows time evolution of Ar excitation temperature at 10 mm below the coil end under experimental condition that SCL is 60 %. Ar excitation temperature shows also a simple behavior corresponding to rectangular change of the rf power.

The ICTPs with plasma properties shown here have been applied to several laboratory experiments including fusion oriented studies[2, 3]. High pressure argon-hydrogen mixture plasmas have been used to study graphite erosion by low energy hydrogen irradiation[4]. The experimental results will be shown elsewhere sonn.

1)Tanaka, Y., et al., Appl. Phys. Lett., **89**(2006)031501.
2) Takeguchi, Y., et al., Plasma and Fusion Res., Rapid Comm., **3**(2008)025.
3) Uesugi, Y., et al., in Proc. 18th Int.Symp. Plasma Chem. ISPC-18, 28P1-4, 2007, Kyoto, Japan.
4) Takeguchi, Y., et al., in Proc. 18th Int. Conf. on Plasma Surface Interactions, PS-10, 2008, Toledo, Spain.

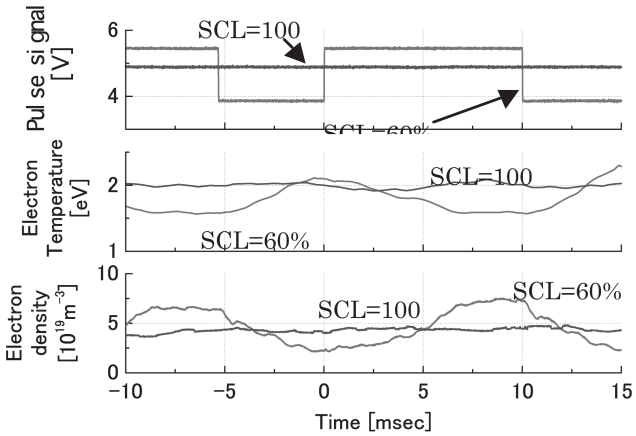

Fig.1 Time evolution of electron density and temperature.

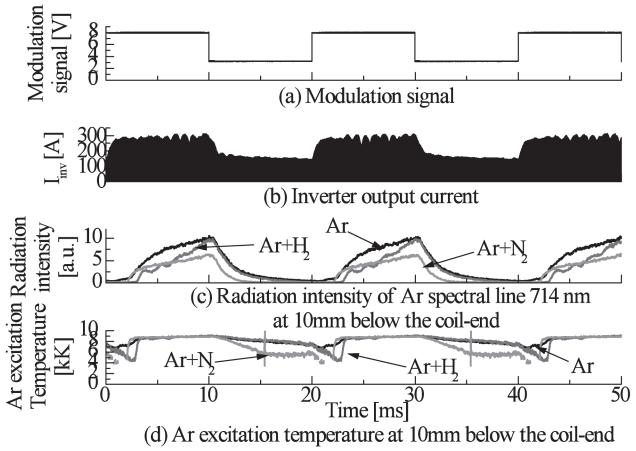

Fig.2 Time evolution of Ar excitation temperature, when SCL is 60 %.